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Spatial and Temporal Analyses of Urbanization of Mardan City, Its Causes, and Impacts on Environment

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Abstract: Urbanization is one of the emerging major problems causing many environmental issues especially in developing world. In this study we analysed the Mardan city temporal and spatial urban expansion by using satellite images of the year 2001, 2008 and 2014. We found a drastic increase in the built up area of Mardan city having adverse impacts on agriculture land, agricultural production, vegetation loss and local biodiversity just in 14 years. The study identified the basic factor as the strong efforts and political well of AwamiNational Party (ANP) government in the region who brought mega projects to this area such as institutions of higher and professional education e.g., AWKUM, BKMC, Campuses of Agriculture and Engineering Universities, Intermediate and Secondary Education Board, Sports Complex and new roads. All these institutional developments brought and triggered a new start of many residential / housing societies both legal and illegal. With this new era of commercialization and increase in shopping centres, new businesses and market chains were launched. Considering it as an opportunity Pak Army having Punjab Regiment Centre (PRC) in the heart of Mardan city with a lot of fallow land started buildings and commercial plazas as well. Thus, PRC played another very active role in developing and expanding the Mardan City. Thus, these were the driving forces behind the rapid expansion of Mardan city in a very short time. Our results showed that Mardan expanded on the most fertile and agriculturally available land, causing agricultural and biological decline as well as a negative impact on water quality.
We therefore recommend that the Local Government needs to address the problem of haphazard urban growth and its associated problems, which definitely need a proper planning and policy for future land use cover and change. The local government must identify the sites suitable for housing societies keeping in view all the rules and regulations with a strict EIA implementation. Illegal residential societies must be banned, and strict action should be taken against them. The Government and other line agencies must take serious action for its conservation and may give attention to provide basic needs to rural population that will decrease local's migration to urban areas.
Keywords: Land use change; Urbanization; Vegetation and Biodiversity loss; Mardan City; Pakistan

INTRODUCTION

Urbanization is known as the continuous growth in population, density, or amount of residential area time wise and also its increase in spatial scale is called urban expansion, which has long been considered a sign of regional economic vitality as well (Alig, et al., 2004).

Commonly urbanization is a change in land uses with passage of time related with population growth and economy and therefore urbanization is one of the major cause of land use and land cover change and its associated problems in developing countries (Glaeser and Henderson, 2017; Shen, *et al.,2017* ; Glaeser, 2014). Urban expansion has usually great and negative impacts on climate change and environmental issues like deforestation, threat to watershed resources and increase in air pollution, desertification and flooding (Mahmood, *et al., 2014* ;Butt, *et al.,2015* ; Thorner, *et al.*, 1986; Mather, 1986).The work on urban expansion and its impact on surface temperature in Zhujiang Delta of South China, showed that because of irregular urban growth the surface radiant temperature has increased by 13.01K in their study area during 1989 to 1997 (Weng, 2012).SimilarlyinKalam area of Pakistan, the forest area decreased by 30.5%; while 11.4% of the deforestation caused by agricultural expansion and agricultural area was decreased by 17.3% and converted to rangeland due to rapid increase in population and urbanization (Qasim et al., 2011).

Most of the built-up areas have low biodiversity because of urbanization and its expansion impacts on local species from local to regional level. It is because when development starts, the developer removes vegetation and even topsoil to clear the area for construction. The impact of the change in the

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green cover is quite obvious as the habitats of many species are vanished and new strains of diseases such as dengue etc, spread at an enormous rate in recent past (Shirazi and Kazmi, 2013 ; Sharpe,et al.1986).

Urban expansion and succeeding land use changes governed by geographical and socio-economic factors, like population growth, policy and economic development or because of their combinations, is a common phenomenon in most of the development countries (Xiao et al., 2005; Cohen, 2006 ; Jiang and O'Neill, 2017). For example, land use patterns of urban outskirts are changed in pursuit of high economic returns like, orchards and croplands changing to vegetable land because of industrialization, transport access, and infrastructure (Jiang, et al. 2013; Xiao, et al.2005).). Especially in developing countries the current rate of urbanization is high because of better employment but at the same time unplanned urban growth is often associated with poverty, environmental degradation and population demands that outstrip service capacity (Fazal, 2000; Chhetri and Lama, 2014).

Like other provinces in Pakistan, the Khyber Pakhtunkhwa has also undergone a rapid growth in urban population since independence in 1947. The total shift from rural to urban area rose from 11% in 1951 to 17 % in 1998 and is likely to increase by 18% in 2006 (Rahim, et al., 2007). Although in Khyber Pakhtunkhwa major population lives still in rural area but in past few decades' rapid growth estimated in urban population. With reference to this province basic facilities such as developmental centres, community centres, education and health facilities and better road infrastructure attract population to move from rural to urban areas or its outskirts causing urban expansion (Rahim, et al., 2007; Shirazi and Kazmi, 2013). The conversion of agriculture land to residential and commercial area emerges harmful consequences on environment. Especially in Peshawar, Mardan and other major cities in the province the urbanization rate is very high (Malik, and Ali, 2015). In developing countries like Pakistan, a rapidincrease in urbanization and its direct threat to natural vegetation and specially agriculture land degradation is very common. Mardan city is of the developing city where the urbanization is increasing with a very high rate. Therefore, the study on documenting the urban Expansion of Mardan city and analysing its causes and impacts is quite important and necessary.

Remote Sensing in the context of geographic information systems and advancement of satellite technology, especially the recent availability of high-resolution satellite remote sensing images and Digital Ortho-photography Quadrangles (DOQs), provides an improved ability to assess environmental effects of urban expansion at local scales (Fei Yuan, 2007). Therefore, many researchers studied urban expansion, land use change and its impact in different aspect with the help of GIS. The aim of this research was also to analyse the causes and impacts of Mardan city urbanization using GIS. The research focussed on urban expansion of the city and its impact on vegetation loss between 2001, 2008 and 2014.Major objectives includes to quantify the land use and land cover change in study area due to urbanization, to quantify the impact of urbanization on vegetation loss and to know the major causes and consequences of urbanization in the study area. We also focussed on the losses in agricultural production due to land use change in the wake of food security and sustainability on regional level.

Study Area

Mardan District lies between 34° 05' to 34° 32' North latitudes and 71° 48' to 72° 25' East longitudes. Mardan is the second most populous city (population is 23.7 million in 2014) in the province of Khyber Pakhtunkhwa and the 19thlargest city of Pakistan. Mardan is the headquarter of the district having an area of 1,632 km^2 and total population of 2.4 million (GOP, 2014). Map 1 shows the study area location on Pakistan map.

Mardan district has two main regions, North-eastern hilly area and southwestern plains. The Northern side of the district is bounded by the hills while the south-western area is composed of fertile plains with low hills. The summer season is extremely hot. The temperature goes high than 43.50°C in the month of June. However, a rapid fall in temperature has been recorded from October onwards. Most of the rainfall occurs in the month of July, August, December, and January. Maximum rainfall recorded for the month of August the rainiest month is 125.85 mm (District profile of Mardan).

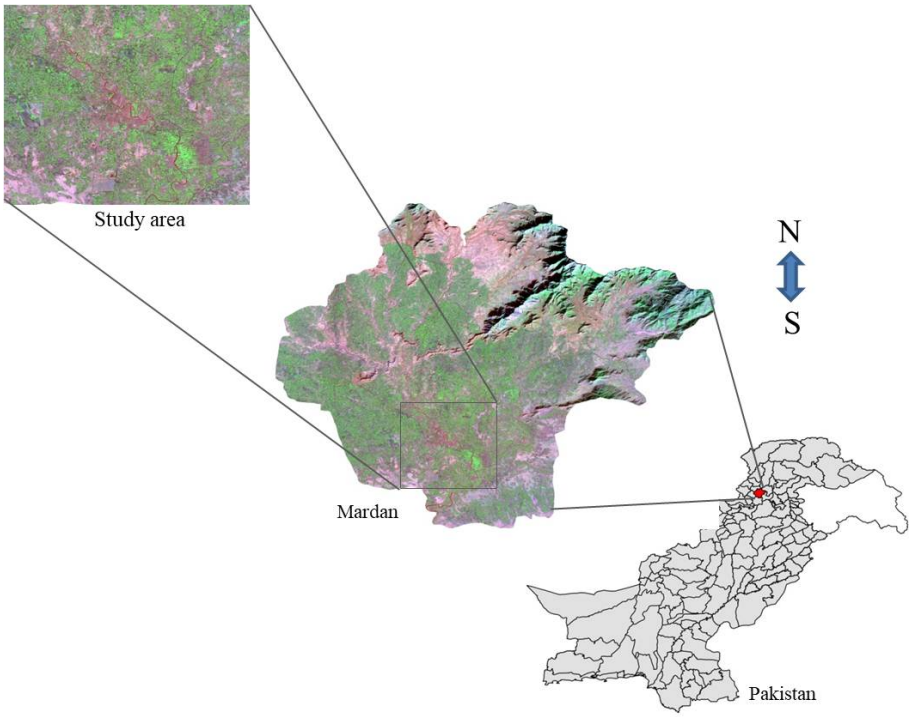

Figure 1. Study Area Location on Pakistan Map

METHODS AND MATERIALS

Geographic Information Systems (GIS)has been widely applied and been recognized as a powerful and effective tool in detecting urban land use and land cover change because GIS technology provides a flexible environment for entering, analysing and displaying digital data from various sources necessary for urban feature identification, change detection and database development (Ehlers et al. 1990; Treitz et al. 1992 ; Harris and Ventura 1995 ; Weng, 2001; Kucukmehmetoglu and Geymen, 2007 ; Rawat and Kumar 2015).

As the literature shows, that GIS and Remote Sensing is the best and the only accurate way to conduct research on spatial and temporal changes in land use, I therefore have used GIS and Remote Sensing for pursuing my research objective.

Data Collection

Satellite Data

Three satellites images of the study area having coordinates 34^0 14'04" latitude and 72 ^{0} 06' 34" longitude for the year of 2001, 2008 and 2014 were purchased from Space and Upper Atmosphere Research Commission (SUPARCO) archives. As per quotations from SUPARCO, all images employed in the present study for 2001 were SPOT-2 XS (20 m resolution, Level 1B) standard colour digital images. While data used for 2008 and 2014 was SPOT-5 Pansharpen (2.5 m Resolution, Level 2A) standard colour digital images.

Image Interpretation and Map Analysis

The three images were co-registered to the 2014 image in ERDAS Imagine 9.1. The 2001, 2008 and 2014 images were matched with the geometrically corrected OLI images from 2014 by means of an image-to-image matching method provided by the ERDAS Imagine software following Jensen (2005) and Leonardob (2006).

Land cover classification scheme

Supervised classifications with maximum likelihood were performed in ArcGIS 10.3.1 on all images. For each class, 20 ground-truth polygons were digitized based on visual analysis of locations on Google Earth and the image itself. To improve classification, training polygons with confusing spectral signatures were discarded and new ones created based on a visual analysis of the locations on Google Earth and on the image itself and the maximum likelihood algorithm was run again following

the methodology used by Fonji and Taff (2014). In the results chapter Figure2, Figure3 and Figure4 show the final output of the supervised classification, which consist of three classified maps of Mardan city 2001, 2008 and 2014respectively.Raster calculator was used to detect land use and cover changes following the methodology used by Shalaby & Tateishi, 2007 and Qasim et al. 2011, through which a land use and land cover change map and matrix were produced. This matrix provides essential information about nature and spatial distribution of land use changes. A change matrix enable for the main types of changes or directions in the study area.

RESULTS AND DISCUSSION

Mardan is located in Khyber Pakhtunkhwa province of Pakistan. Mardan is famous for its major agriculture production because of its fertile soil. Major agriculture land of Mardan city is now changing to some of urban and commercial areas due to increase in population and for economic purpose. Spatial and temporal analysis of urbanization in Mardan city, the study conduct for the year 2001 from SPOT-2 having 20 m resolution while the other maps developed for the year of 2008 and 2014 from SPOT-5 having 2.5 m resolution. Land use maps were created from these satellite images having three land cover types namely, built up area, agricultural land and water body (Figure 2, 3 and 4). The description of each land cover type is given in the table 1. From the analysis of maps for this study we have identified some major transformation among different land cover types. The detailed results, analysis and discussion is in the following sections.

Table 1. Land-cover classes (Km^2/%) for the years 2001, 2008 and 2014

Year	Built up Area		Agricultural Land		Water Body	
	Km^2	% age	Km^2	% age	Km^2	% age
2001	15.51	9.84	141.14	89.52	1.02	0.65
2008	23.90	15.16	132.58	84.09	1.19	0.76
2014	55.60	35.27	100.63	63.83	1.44	0.92
Total Area	**157.67 Km^2**					

Urbanization is usually a threat to the agricultural land in many developed and developing countries, with the increase in economic status usually people are more engaged in developmental activities, for with the fertile agriculture land is usually the easy target to be converted to non-agriculture land. Mardan district population in 2014 was 23.7 million. Urbanization due to increase in population and its pressure on natural resources is quite a common phenomenon. With the increase in population usually rural people move to nearby towns and cities (Cohen, 2006).

We found that during the study period Mardan city has expanded, especially the built up area from 2001 to 2014 with a significant loss or consumption of agricultural land. The tremendous change found particularly from 2008 to 2014 where the total urban area increased by 37.17km^2 consuming 36.86 $Km^2$of agriculture areas. It also shows that rural people have also been moving from rural areas to urban areas. (Fazal, 2000) studied the urbanization of Indian city, “Saharanpur” for a ten years period from 1988to 1998 the unplanned urbanization effect 38 hectares of high fertile agricultural land was used for built up area. In this study we observed that during 2001 to 2008 we lost 8.56 Km^2 agricultural land, that could have produced 1,575.04 tons of wheat or 1,848.104 tons rice per annum, while in 2008 to 2014 we lost 31.95 Km^2 of agricultural land that is equivalent to 1,46,672.865 tons of sugar cane production on annual bases. Our results are quite similar to (Malik and Ali, 2015) who also reported that urbanization directly affected agricultural productivity in Peshawar valley. We particularly focussed on the area within the newly built ring road, which was about 157.67 Km^2. Major three classes of variation in land use and land cover status of year wise is given in table 1 and figure 2, 3 and 4.

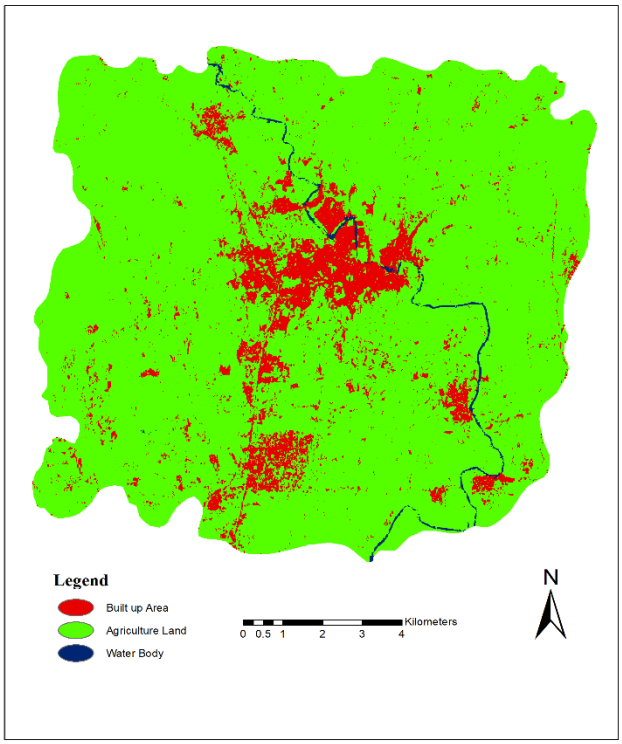

Figure 2. Land use/land cover status in 2001

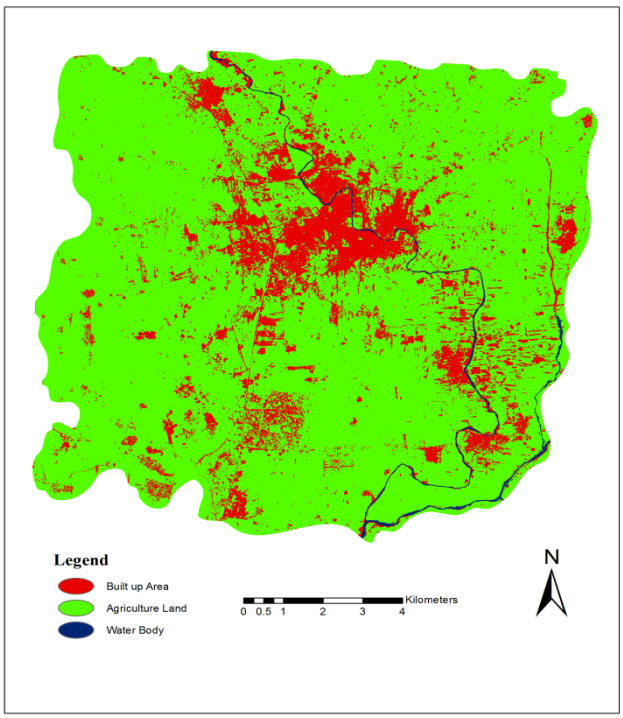

Figure 3. Land use/land cover status in 2008

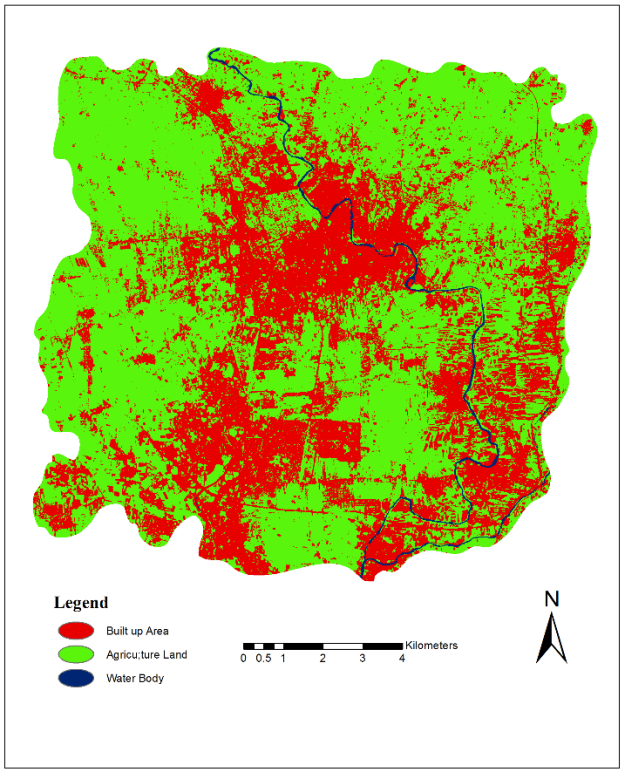

Figure 4. Land use/ land cover status in 2014

Land use/ land cover status of 2001, 2008 and 2014

The land use/cover for the year 2001, it is clear that Built up area was 15.51 Km^2 (9.84%), Agricultural land was 141.14 Km^2 (89.52%) and the Water Body was 1.02 Km^2 (0.65%) as shown in (table 1 and fig 2). The land cover classes shown in fig 3 calculated from the map has been given in Table 1 which shows Built up area was 23.90 Km^2 (15.16%), Agricultural land was 132.58 Km^2 (84.09%) and the Water Body was 1.19 Km^2 (0.76%). Both visual and quantitative differences are quite high and visible from the maps of the two years. From the analyzed results in (Table 1 and Figure 4) shows that in 2014 Built up area was 55.60 Km^2 (35.27%), Agricultural land was 100.63 Km^2 (63.83%) and the Water Body was 1.44 Km^2 (0.92).

Major land use/cover changes between 2001 and 2008

During study period of 2001 to 2008 land cover changes are describe in table 2. The major three classes (Built up area, Agriculture land and Water body) are discussed in table 6. The Built up area increase 8.39 Km^2 (5.33%), Agriculture land decrease 8.56 Km^2 (5.59%) and Water body area change is 0.17 Km^2 which is negligible as a whole. According to the recent study of (Glaeser and Henderson, 2017) they analyse the due to increase in urbanization billions of peoples facing urban issue across the world.

Table 2. Land use/ cover change between 2001 and 2008

	Land cover 2001 Km^2	**Land cover 2008 Km^2**	**Area change Km^2**	**% Change**
Built up Area	15.51	23.90	8.39	5.33
Agricultural Land	141.14	132.58	8.56	5.59
Water Body	1.02	1.19	0.17	0.11

Total	**157.67**	**157.67**		

Major land use/cover changes between 2008 and 2014

During the study period from 2008 to 2014 of six years the land use and land cover change in high level mostly built up area expand a very high speed on the cost of agriculture land. These major changes are described in (Table. 3 and Fig.5). The built up area increase 31.7 Km^2 (20.11%) and the agriculture land degrade 31.95 Km^2 (20.27%). The results shows a significant reduction in agriculture land cover. According to (Table 3) which was prepared using satellite images via GIS techniques,shows the type of land use transformations. The major land cover loss is in the agricultural land that was transformed or used for built up area.The impacts of urbanization on agricultural land loss in India from 2001 to 2010, the total area of agricultural land lost to urban expansion has been relatively low, in since 2006, the amount of agricultural land converted has been increasing steadily. Given that the preponderance of India's urban population growth has increase constantly (Pandey and Seto., 2015).

Table 3. Land use/ cover change between 2008 and 2014

Land use and land cover classes		**2014**		
		Built up Area	Agricultural Land	Water Body
2008	Built up Area	18.45	5.16	0.37
	Agricultural Land	36.86	94.89	0.55
	Water Body	0.31	0.38	0.52

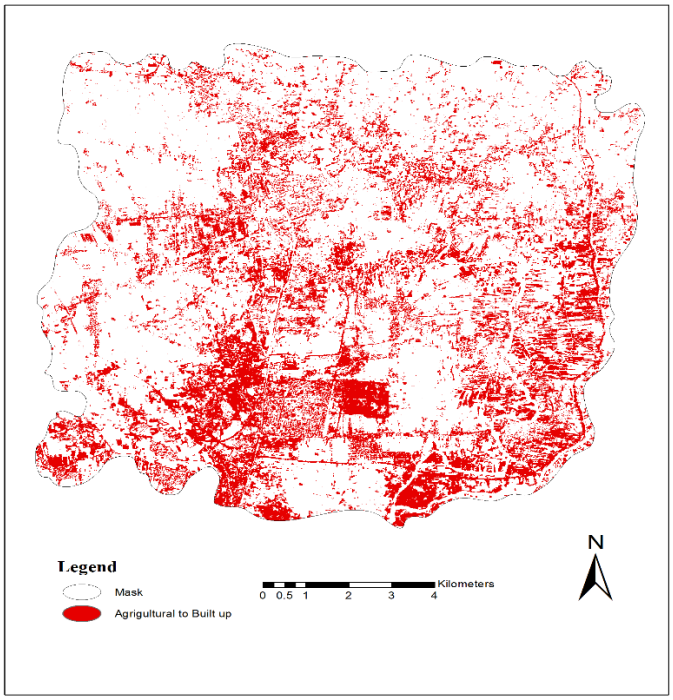

Figure 5. Major land use changes in (2008-2014)

Major land use/cover changes between 2001 and 2014

The total land use change from the year of 2001 to 2014 of fourteen years the land use and land cover change are discussed in table 4. The major change in Agricultural land degradation 40.51 Km^2 (225.69%) due to increase in built up area 40.09Km^2 (25.43%). These land cover change are due to rapid

increase in urban expansion. The study conduct in Pokhara valley on the relationship among urbanization, land use/land cover dynamics and risk analysis of the years from 1990 to 2013. In the 23-year period, the built-up area more than doubled from 24.03 km² to 54.20 km². Although the landscape in the urban, peri-urban and rural areas appears to be fragmented, different drivers play an important role in landscape change in these areas (Rimal, et al., 2015).

Table 4. Total land use/cover changes between 2001, 2008 and 2014

Land cover	**Year wise area in Km²**			**Change in land cover in Km²**		
	2001	2008	2014	Period 1	Period 2	Total
Agricultural Land	141.14	132.58	100.63	8.56	31.95	40.51
Built up Area	15.51	23.90	55.60	8.39	31.7	40.09
Water Body	1.02	1.19	1.44	0.17	0.25	0.42
Total Area	**157.67**					

Governmental and Political Drive

In history of Pakistan, ANP "Awamy National Party" for the first time won provincial elections with heavy mandate in 2008. The Chief Minister of Khyber Pakhtunkhwa "Mr Amir Haider Khan Hoti" took it both as a challenge and chance to work for the development of the province. He belonged to Mardan and therefore many developmental projects were started in the district. Following are some of the details of major and minor projects that started or completed in that era. For better understanding, as figure 6 shows, we have divided Mardan city in two different parts. It is very interesting that for both the parts we have different driving forces for increase in built up area.

Mega Projects

The location and area for mega projects have been shown with green colour in the map (Figure 6). We call it mega projects because most of the projects were funded by government as well as private sector. Such projects included Abdul Wali Khan University, Bacha Khan Medical College, Mardan Sports Complex, Sheikh Maltoon Town, Green Acres Town, Mardan Central Jail, Gulberg Town and Mardan Ring Road and Motorway. Because of these major developmental projects the nearby areas have also been affected. In literature many studies have confirmed economic growth as well as urbanization (Wheeler et al 2005; Chandra and Thompson, 2000).

It is very important to note that these mega projects were mostly carried out in previously agricultural land, or in other words Mardan expanded in this direction because of land availability and Motorway access.

Minor Projects

Second side of Mardan city is developed from some minor projects as show in Fig.6 having reddish colour. Minor projects included PMS Residential Complex and some others minor projects. Punjab Regiment Centre is in centre of Mardan city. Over the last couple of years, they have been started many commercial buildings in various locations of the cant. Such building expansion has been showed by various pictures taking during the study period.

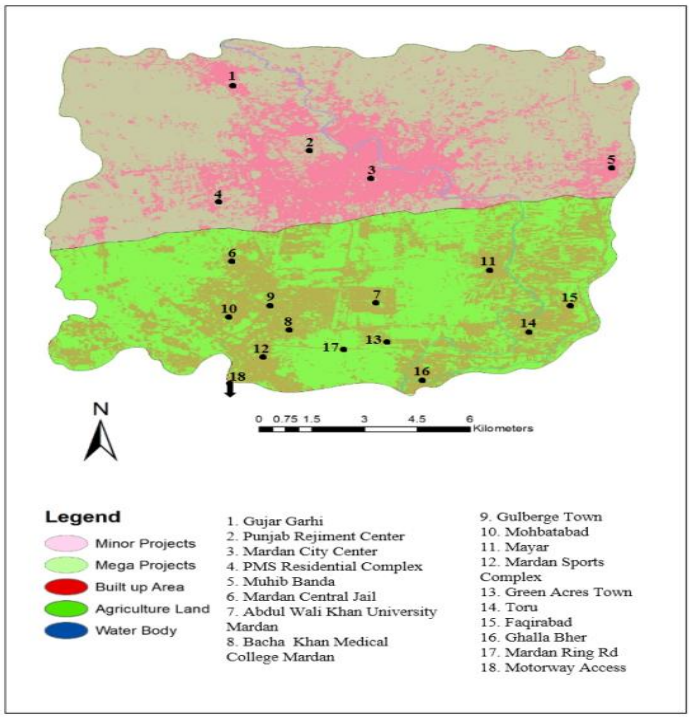

Figure 6. Major and minor projects location in Mardan city

CONCLUSION AND RECOMMENDATION

Now a day's urbanization is emerging as a major environmental problem. The literature shows that urbanization is mostly because of increase in population, people migration from rural to urban areas for basic needs of daily life. In this study we analysed the Mardan city urban expansion, its causes and environmental consequences over the last one and a half decade.

To study the temporal expansion of Mardan city we used satellite images of the year 2001, 2008 and 2014 purchased from SUPARCO Islamabad. The analyses of urban expansion and its impact on agriculture land, agricultural production, vegetation loss and local biodiversity are quite significant. Our results showed that just in very short time of fourteen years the total urban expansion or increase in built up area was 25.43 %, and all this increase in built up area caused the same amount of agricultural land loss. The study further identified few basic factors that are responsible for urban expansion with such a high rate. The first major cause identified was the launching of new developmental major project such as building the new ring road that made the access to many plane agricultural areas adjust to motorway. Apart from ring road the other mega projects brought to Mardan by ANP government were institution of higher and professional education such as AWKUM, BKMC, Campuses of Agriculture and Engineering Universities, Mardan Board, Sports Complex and a network of new roads. All these institutional development brought and triggered a new start of many residential / housing societies. With all such new era commercialization and increase in shopping centres, new businesses and market chains are natural to be launched. Taking opportunity of this era, Pak Army having Punjab Regiment Centre (PRC) in the heart of Mardan city, with a lot of land started building commercial plazas and buildings. Thus PRC played another very active role in developing and expanding the Mardan City built up area. All these factors were basically the driving forces behind the rapid expansion of Mardan city in a very short time.

Based on our research on analyses of urbanization of Mardan city and its environmental impacts, our recommendation are that, the Local Government needs to address the problem haphazard urban growth of Mardan city and its associate problems, which definitely need a proper planning and policy for future land use cover and change. The local government must identify the sites suitable for housing societies keeping in view all the rules and regulations with a strict EIA implementation. Illegal residential societies must be banned and strict action should be taken against them. Conservation of

agricultural land and local biodiversity is very important. Local Government and the other line agencies must take serious action for its conservation.

Federal as well as provincial Government must give attention to the developmental projects and facilities in rural areas, so to develop their life standard up to certain level. This will make sure the sustainable agriculture in rural areas.

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